

# I/O News

Volume One, Number Two

The OFFICIAL PUBLICATION OF THE INTERNATIONAL ASSOCIATION OF CROMEMCO USERS

## Cromemco's New Small Computer Gives the User a Lot of Expandability

### Offers enormous software support

Cromemco recently announced its feature-loaded System Zero computer.

Basically, the System Zero is a physically small, but powerful Z-80A computer designed for dedicated or general purpose situations where programs are likely to be of the small ROM-based type.

But the System Zero has expandability written all over it. Thus it has three additional card slots to permit plugging in more memory on I/O cards, and even to interface with Cromemco's floppy disk system.

Cromemco is also introducing a second version of the System Zero known as the System Zero/D. This system consists of the computer and dual floppy disk drive storing 390 kilobytes on each of two 5-inch diskettes.

The System Zero/D is provided with the Cromemco Z-80A single-card computer and 64K of fast RAM.

In addition, it has the Cromemco 16FDC controller card which has several special features. One is the new resident disk operating system, RDOS-2. This gives the system the ability to read or write single-sided, double-sided, single-density or double-density diskettes. The

*Continued on page 19*

New Cromemco System Zero/D (lower unit) with Model DDF Disk Drive. System Zero is identical in appearance to System Zero/D.

Expandability without need for changing systems or re-doing software is a particular attraction of these systems.

Model DDF can store 390 kilobytes on each of two 5-inch diskettes.

Self-test diagnostics are part of new RDOS-2 operating system in disk controller.



### ACTIVE COMMAND FILE: AN UPDATE

### STRUCTURED PROGRAMMING IN BASIC

### PROCESS CONTROL IN OIL FIELDS

## A New Approach to System Design: The C-Bus, IOP, and QUADART

by Curt Terwilliger

The architecture of S-100 systems hasn't changed much since the bus was introduced in 1975. A typical system includes a CPU, memory, and I/O cards. True, the performance of each card has been improved over the years, what with the advent of the 4 MHz Z80s, 64K ram cards, quad density floppies, and hard disks; but broadly speaking all systems look pretty much like they did a few years ago.

The introduction of the C-bus by Cromemco brings new architecture and powerful performance to the S-100 bus through the addition of multiple processing systems. These systems are based on an I/O pro-

*Continued on page 22*

## Purchasing A Computer System — Major Contract Issues

by Gilbert N. Kruger, Esq.\*



As is the case with many complex commercial transactions, purchasing a computer system involves many important considera-

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\*Gil Kruger is a partner in the law firm of Malcolm & Daly, Newport Beach, California. He is also on the Board of Directors of The Computer Law Association, a national association of attorneys involved in computer law, and a former Staff VP/Ass't. Gen'l. Counsel at Automatic Data Processing, Inc. (ADP), a NYSE listed computing services firm.

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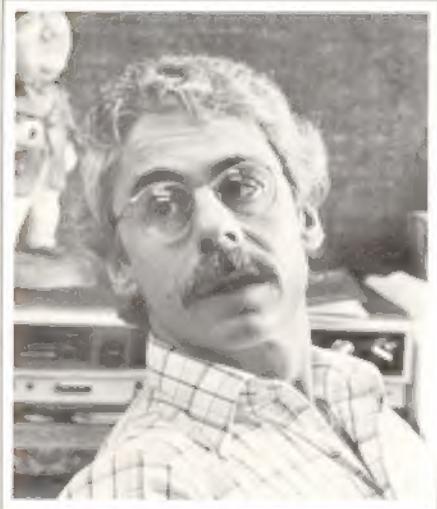
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Richard Kaye  
Editor and Publisher

Kathryn Ann Butler  
Editorial Assistant

# output...



## THANK YOU IACU MEMBERS!

Your response to our first issue was even better than we hoped. We are happy you like our efforts, and will try to keep the quality where you want it. Many of your letters included tips and suggestions which we have either incorporated or have printed on pages 30-31.

We also received some more, excellent articles, a few of which appear in this issue. The rest will appear in future issues. Please keep those articles coming. It is only through the "real world" experiences and applications of our members that we will be able to maintain our quality.

### BOOKS

One of our early members, Rodney Zaks, sent us copies of two of his latest books. And just in time! My knowledge of microprocessors, prior to my involvement in The IACU, was minimal. **YOUR FIRST COMPUTER — A Guide to Personal and Business Computing** by Rodney Zaks (SYBEX, Inc., Berkeley, California) is precisely what I needed.

It is a comfortably written book (280 pp.), that gently leads the reader from a head-scratching starting point into the more complex aspects of microprocessors. Zaks appears to write from the assumption that the novice computerist of today is truly a novice.

The book teaches the most rudimentary terminology, then proceeds to build onto the basics, layer by layer. By the time the reader gets to the third chapter, **BASIC DEFINITIONS**, he has already absorbed enough basic definitions to allow his learning curve to rise sharply throughout the chapter.

Overall, Zaks takes a very gentle, and subtly effective approach to teaching the principles of computing and computers. And, it is the gentleness of his approach that makes this such a good starting point for people like me — people who had virtually no preparation for the microprocessor revolution, but had better get into the mainstream this decade, or be left behind.

**YOUR FIRST COMPUTER** belongs not just in every public library, but in the library of every business that needs, or will need computers. To me, that means every business that hopes to stay in business.

### AND MORE BOOKS

On the subject of new publications by members, we received an excited call from a member about a new book, **Basic FORTRAN** by James S. Coan (also the author of **Basic BASIC**). The ink was still wet when we took the report on this introduction to FORTRAN. According to the reviewer, it is chock full of examples followed by full sets of problems at the end of each chapter. (Not to worry — answers are provided at the back of the book.)

Coan takes a direct, no-nonsense approach to introducing FORTRAN to the beginner who wants to teach himself this prime language — and he provides all the tools necessary to ensure success.

**Basic FORTRAN** is published by Hayden Book Company, Rochelle Park, New Jersey. (Stock # 5168-9)

### GUEST COLUMNIST

This page is too big for just one person, so here's an offer we hope you cannot refuse. We would like to feature a "Guest Columnist" each issue. And, we would prefer to see this space devoted to your opinions or even "pie-in-the-sky" ideas as to where micros are going — what effects they will have on our lives. We will select one (or more, depending on length) for publication each issue. Act quickly and be the first Guest Columnist.

Richard Kaye  
Editor & Publisher



# Structured Programming In Basic

## A Discussion and A Morse Code Generator

By Mark G. Sobell

This article is an introduction to some of the concepts and techniques of **structured programming**. It discusses the ideas behind program modularization and its implementation using **procedures**. Also covered are **basic control structures** and their relationship to linear program flow.

Some of the elements of this discussion are put to practical use in the program **Morse**, a Morse code generator.

"Why structured programming?" You may ask. "Structured programming is for professionals, large programs, and students of computer science."

It used to be that way. But now, more and more people are realizing that the time put into both learning the techniques of structured programming and into writing structured programs pays off in time saved debugging and maintaining these programs, not to mention the improvement in the reliability of the programs.

The language of choice for this discussion is **Cromemco 32K Structured Basic**.

It is a good language for the programmer who is developing structured programming skills. Most people who have had any contact with computers already know, or can readily learn, Basic. This means that all of the learning concentration can be focused on the techniques of structured programming, not on a new language.

Basic is a **friendly** programming language which is easy to learn and use. It is an **interactive** language which means that changes can be made to a program while it is running. These are useful features for the student of structured programming, allowing a lot of room for experimentation which is a necessary part of the learning process.

Yet, Structured Basic is professionally oriented as can be seen from the example at the end of this article. Being an interactive language, it is a lot easier to debug than a compiled language. This means that the time spent learning structured programming through Basic can be put to programming use immediately.

Two of the most important aspects of structured programming are program modularization and linear, or orderly, program flow.

### Modularization and Procedures

One of the key concepts of structured programming is **modularization**. Modularization is breaking a program down into simple, logical parts.

Simplicity is the essence of structured programming. The reason that a structured program is more likely to work the first time it is executed is the same reason that it is easier to debug: the

program has been broken down into small, simple, logical parts. These parts are much easier to work with than the large tangled mess of a conventional program. Also, each of these parts can be independently tested so that when they are combined, the only untested portion of the program is the way in which the modules interact.

Cromemco 32K Structured Basic allows the programmer the option of dividing the area of memory which is dedicated to the user into as many as eight memory partitions. Each of these partitions can contain a single procedure or group of related procedures.

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Mark G. Sobell is manager of the Technical Publications Department at Cromemco. He has been with Cromemco for the past 2½ years and has worked with computers for 7 years.

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Each partition has its own set of variables, statement labels, and line numbers. When a procedure in another partition is called, values and variables may be passed to it and returned from it.

The following example illustrates the concept of program simplification and modularization through the use of procedures. It is the skeleton of a routine which is designed to retrieve input from the console.

For simplicity, these procedures do not deal with necessary aspects of this type of routine such as checking for errors, illegal or non-printing characters, passing parameters, etc. Assume that each of these procedures has access to a common variable. This variable acts as a storage buffer for the string which is being read from the console and processed by the routine. We shall name this (string variable) buffer **Buffer\$**.

```
Procedure .Read' console' no' blanks' no' null
Call .Read' console' no' blanks
Call .No' null
Endproc
```

```
Procedure .Read' console' no' blanks
Call .Read' console
Call .No' blanks
Endproc
```

```
Procedure .No' blanks
Call .Strip' leading' blanks
Call .Strip' trailing' blanks
End proc
```

```
Procedure .Read' console
Rem This procedure accepts a
Rem string Buffer$ from the
Rem console.
Endproc
```

```

Procedure .Strip' leading' blanks
  Rem This procedure shifts the
  Rem characters in Buffer$ to
  Rem the left so that the first
  Rem non-blank character is in
  Rem the first position of the
  Rem string.
Endproc

Procedure .Strip' trailing' blanks
  Rem This procedure changes
  Rem all trailing blanks in
  Rem Buffer$ to null characters.
Endproc

Procedure .No' null
  Rem This procedure will reject
  Rem Buffer$ if it contains
  Rem nothing but null characters.
  Rem Note: the user will have to
  Rem be re-prompted.
Endproc

```

#### Calling the first procedure

(**.Read' console' no' blanks' no' null**) will fill the variable **Buffer\$** with a user-input line from the console. As can be seen from the name of this procedure, there will be no leading or trailing blanks in **Buffer\$** nor will it be a **null string** when it is returned to the calling routine.

A null string would normally be generated if the user typed a carriage **RETURN** in response to a prompt to input a string.

The task at hand has been divided into several distinct procedures. Each procedure acts on the common variable **Buffer\$**. The primitive procedures (those which do not call any other procedures) should be written first and may be tested and debugged independently of all of the other procedures.

Following this, the next generation procedure (**.Read' console' no' blanks**) should be written and debugged. This should be a simple matter because most of this procedure is composed of calls to other procedures.

Finally, the most complex procedure should be written and tested. Again, this should be fairly simple because all of the call procedures have already been debugged.

Because we have written this routine in modular form, it may be entered by calling one of several different procedures depending on the type of input which is expected.

In addition to calling the first procedure, **.Read' console' no' blanks** may be called if the programmer wishes to have a null line returned if the user enters a carriage **RETURN** or spaces followed by a carriage **RETURN**.

The primitive procedure **.Read' console** may be called if the programmer has need for all of the user's input.

In summary, we have four very simple procedures:

- .Read' console**
- .Strip' leading' blanks**
- .Strip' trailing' blanks**
- .No' null**

When these are combined in various ways, we have a series of more complex (and more useful) routines.

Additional procedures may be written which will perform error checking for type of input (alphabetic, numeric, floating point, integer,) for illegal or control characters, etc. When these are added to the concepts which have been developed here you can begin to grasp some of the basic ideas of structured programming.

Remember only skeleton procedures are included here and that other statements would, of necessity, have to be included in the routines.

#### Control Structures and Linear Program Flow

Another important aspect of structured programming is that control flows in a linear or sequential fashion. In conventional programs control tends to pass from one section of code to another in a haphazard manner with **Goto** instructions jumping around other **Goto** instructions.

Control structures change the order of execution of instructions from the sequential line number order. The simplest control structure is the **Goto** instruction. When executed, it causes program execution to pass to a statement which is not the next statement number in the program.

Ironically, it is the **Goto**, the simplest of the control structures, which has almost no place in a structured program. **Goto** instructions tend to make it more difficult to follow program logic and therefore make programs harder to debug and maintain. Preferred structures are conditional loops and branches which allow program flow to continue linearly while conditionally repeating or skipping over sections of code.

Cromemco Structured Basic provides a number of control structures which allow the programmer to write clear, concise, understandable programs.

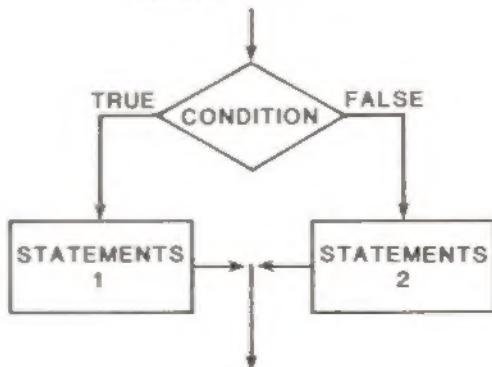
The **If-Then-Else** structure provides a conditional branch followed by two independent sections of code. This means that, based on an expression or the value of a variable, program execution can follow one of two paths. Each of the paths can contain as many basic statements as are required to complete the task at hand.

The English translation of these instructions is: **IF** the condition is true **THEN DO** these (statements-1); **ELSE** (if the condition is false) execute these (statements-2). **ENDDO** provides a termination for the control structure.

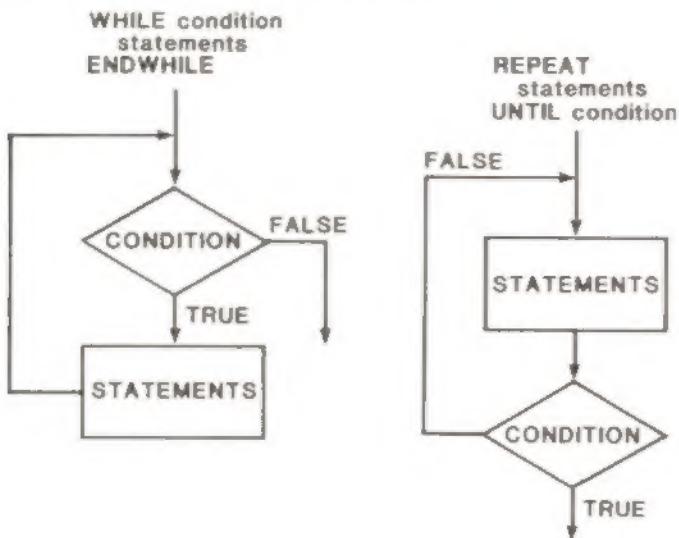
```

IF condition THEN DO
  statements-1
ELSE
  statements-2
ENDDO

```



**WHILE-ENDWHILE** and **REPEAT-UNTIL** are conditional loops. They will both execute a set of Basic instructions over and over again **UNTIL** or **WHILE** a condition is true. The difference between the two is that the **WHILE** structure tests the condition before executing the instructions in the loop; the **REPEAT** tests the condition after executing the instructions in the loop. Because of this difference it is possible for the instructions in the **WHILE** structure to be skipped over entirely, while the contents of the **REPEAT** structure must be executed at least one time.



### A Morse Code Generator An Example of Structured Programming

This program demonstrates some of the concepts of structured programming which have been discussed previously. It does not take advantage of features of Cromemco Structured Basic such as the procedure library, memory partitions, common storage area, procedure parameter passing, etc. It does show a linear, well documented program which incorporates meaningful line labels as well as variable and procedure names.

Note that in a call to a procedure, the key word **CALL** is optional. A procedure may be called by simply referencing the procedure name (which always begins with a period).

The procedure which generates the actual audible Morse code is called **.Tone**. It is designed to take advantage of the Cromemco D+7A I/O interface board as well as a pair of Cromemco Joystick consoles which incorporate amplifiers and speakers for producing audio output. When used without the Joysticks the program will just display the Morse code as a series of dots and dashes on the console.

See program on next four pages.

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```

1000 Rem PROGRAM MORSE
1010 Rem
1020 Rem
1030 Rem Program to convert a text file
1040 Rem to its Morse code equivalent.
1050 Rem
1060 Gosub Initialize
1070 Call .Set'up
1080 Call .Read'and'process
1090 Call .Finish
1100 Stop
1110 Rem- - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - *
1120 Rem- - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - *
1130 *Initialize
1140 Integer Dash'to'dot'ratio,Ies,Ils,Iws,Max'line'length
1150 Rem
1160 Rem The four following parameters control the characteristics
1170 Rem of the code generated and the console display. They may
1180 Rem be changed by the user.
1190 Rem
1200 Max'line'length=75 : Rem Maximum line length on console.
1210 Ies=1 : Rem Inter-element spacing ratio.
1220 Ils=5 : Rem Inter-letter spacing ratio.
1230 Iws=7 : Rem Inter-word spacing ratio.
1240 Dash'to'dot'ratio=3 : Rem This is the standard.
1250 Rem
1260 Rem
1270 Dim Filename$(13),Character$(0),Null$(0)
1280 Dim Valid'characters$(64)
1290 Integer True,False,Error'number,End'of'file'flag
1300 Integer Wpm,Delay,Index,End'of'file'error'number
1310 Integer Num,Low'case,Up'case,P'duration,T'duration
1320 Integer Line'length,Max'line'length
1330 Valid'characters$="aAbBcCdDeEfFgGhHiIjJkK1LmMnNoOprqQrRsStTuUvV"
1340 Valid'characters$(44)="wWxXyYzZ0123456789 .?"
1350 True=l : False=0
1360 End'of'file'error'number=138
1370 Null$=""
1380 Line'length=0
1390 Rem Correct inter-word spacing ratio to follow
1400 Rem inter-letter space.
1410 Iws=Iws-Ils
1420 Rem Correct inter-letter spacing ratio to follow
1430 Rem inter-element space.
1440 Ils=Ils-Ies
1450 Rem Correct maximum line length to allow another character
1460 Rem to be displayed.
1470 Max'line'length=Max'line'length-10
1480 Return
1490 Rem- - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - *
1500 Rem- - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - *
1510 Procedure .Set'up
1520 Print : Print
1530 Rem Prompt user for speed and file name.
1540 Input "Morse code speed (WPM)=",Wpm
1550 If Wpm<1 Then 1540
1560 If Wpm>100 Then @"Cannot be greater than 100" : Goto 1540
1570 Delay=250/Wpm
1580 Input "Filename (XXXXXX.XXX)=",Filename$
1590 Open\l\Filename$
```

```

1600  Endproc
1610  Rem- - - - - * *
1620  Rem- - - - - * *
1630 Procedure .Read'and'process
1640 On Error Gosub Error'trap
1650 On Esc Gosub Escape
1660 End'of'file'flag=False
1670 Get\1\Character$
1680     While End'of'file'flag=False
1690     .Filter
1700     .Decode'and'output
1720     Get\1\Character$
1730     Endwhile
1740 On Error Stop
1750 Endproc
1760 *Error'trap : Error'number=Sys(3)
1770 End'of'file'flag=True
1780 If Error'number#End'of'file'error'number Then Do
1790     Rem Print error message, reset error trap,
1800     Rem and abort program execution.
1810     Print
1820     Print"System Error ",Error'number
1830     On Error Stop
1840     .Finish
1850     Stop
1860     Enddo
1870     Return
1880 *Escape
1890 On Error Stop
1900 .Finish
1910 Stop
1920 Return
1930 Rem- - - - - * *
1940 Rem- - - - - * *
1950 Procedure .Finish
1960 .Break
1970 Close\1\
1980 Print : Print
1990 Endproc
2000 Rem- - - - - * *
2010 Rem- - - - - * *
2020 Procedure .Filter
2030 Rem
2040 Rem The following instructions locate the character
2050 Rem in a string of valid characters. If it is not
2060 Rem found a -1 is returned indicating that it is an
2070 Rem invalid character. If the character is valid
2080 Rem it is displayed else the character buffer is set
2090 Rem equal to the value of a null character.
2100 Rem
2110 If Pos(Valid'characters$,Character$,0)=-1 Then Do
2120     Rem If it is a carriage return, display a space.
2130     If Character$=Chr$(13) Then Call .Space
2140     Character$=Null$
2150     Else
2160     Print Character$;
2170     Line'length=Line'length+1
2180     Enddo
2190 Endproc
2200 Rem- - - - - * *

```

```

2210 Rem----- *
2220 Procedure .Dot
2230   .Tone (1)
2240   Print ".";
2250 Line'length=Line'length+1
2260   .Pause (Ies)
2270 Endproc
2280 Rem----- *
2290 Rem----- *
2300 Procedure .Dash
2310   .Tone (Dash'to'dot'ratio)
2320   Print "-";
2330 Line'length=Line'length+1
2340   .Pause (Ies)
2350 Endproc
2360 Rem----- *
2370 Rem----- *
2380 Procedure .Space
2390 Rem Call Pause with inter-word pause value (Iws).
2400 Rem Display a space on the console.
2410   .Pause (Iws)
2420   Print " ";
2430 Line'length=Line'length+1
2440 Endproc
2450 Rem----- *
2460 Rem----- *
2470 Procedure .Pause (P'duration)
2480 Rem Pause for P'duration times dot value.
2490   For Index=1 To Delay*P'duration
2500     Next Index
2510 Endproc
2520 Rem----- *
2530 Rem----- *
2540 Procedure .Tone (T'duration)
2550 Rem Generate tone for T'duration times dot value.
2560 Rem Joystick speakers must be connected to output ports 25 and 27.
2570 Rem Noesc, Esc sequence allows for faster execution so that
2580 Rem a higher frequency tone is generated.
2590 Noesc
2600   For Index=1 To Delay*T'duration
2610     Out 27,0 : Out 27,128
2620     Out 25,0 : Out 25,128
2630     Next Index
2640 Esc
2650 Endproc
2660 Rem----- *
2670 Rem----- *
2680 Procedure .Break
2690   Print : Print"Break";
2700   .Pause (Ies+Ils+Iws)
2710   .Dash : .Dot : .Dot : .Dot : .Dash : .Dot : .Dash
2720 Endproc
2730 Rem----- *
2740 Rem----- *
2750 Procedure .Decode'and'output
2760 Rem
2770 Rem Check for number.
2780 Num=Asc(Character$)-Asc("0")+
2790 On Num Gosub Zero,One,Two,Three,Four,Five,Six,Seven,Eight,Nine
2800 Rem

```



The main program starts with identifying and explanatory remarks and then calls the four primary procedures which comprise the program. Notice that just by reading the dozen or so lines of code in the main program one can get a good idea of the structure of the entire program.

The first procedure called initializes, types, and dimensions all of the program variables. Cromemco's 32K Structured Basic is still a friendly language. This program would run just as well without any of the variable type statements. It would run slightly slower and take up just a little more memory. This is not significant.

What is significant is the idea of a well thought out program. Ideally the programmer knows what variables are going to be required to accomplish the task at hand before the code is written. Realistically it may take one or two tries at writing the program before all of the problems which will be generated are uncovered.

With or without the variable type declarations the programmer should think carefully about what the program is going to accomplish, how to break it down into its simplest parts, and how to write Basic routines which will be easy to understand.

Four user changeable parameters are clearly identified at the start of the initialization procedure. The spacing ratios assume that the length of the dot is equal to one unit. The actual length of the dot is dependent on the speed (wpm) which is selected when the program is run.

The default values selected here are a space (or pause) equal to one dot after each element (dot or dash,) a space of five dots after each complete letter, and a space of seven dots after each word.

The main program continues with three procedure calls and a stop instruction.

The procedure **.Set' up** does just that one might thing it would do. It sets up the various parameters for program execution. This is accomplished by prompting the user for the needed information and opening the specified file.

Next it is necessary to read the file and process the information. A good name for this routine would be **.Read' and' process**.

The first items of business for **.Read' and' process** are the error and escape traps. No matter what else happens, the input file must be closed before control is returned to the user. If this is not done it is possible that the file will be left opened after an aborted run and the program will not function properly if another **Run** command is given. The error trap is also used to set the end-of-file flag (**End' of' file' flag**) to true (True) when an end-of-file is encountered.

The heart of the program is the following **While Loop**. It is preceded by a single file access which determines if the file is empty (the end of file flag is set to true if it is empty). If the file is not empty the character buffer (**Character\$**) is initialized.

If the end-of-file flag is true upon the first execution of the **While** instruction the statements which comprise the **While loop** will not be executed and the procedure will terminate.

While the end of file flag is false, the characters will continue to be processed. When an end of file is

encountered during a file access, the run time error will be trapped by the **On Error** instruction and control will be transferred to the subroutine **Error' trap**.

If the error trap subroutine is called with the error number equal to the end of file error number then the end of file flag will be set to true and the **Return** instruction will cause program control to be passed to the instruction following the one which generated the error. In this case the **Get** instruction would have generated the error and control will return to the **Endwhile** instruction. **Endwhile** causes control to be returned to the **While** statement. Because the end of file flag has been set to true the condition for the execution of the **While loop** will not be satisfied and control will pass to the instruction following the **Endwhile** instruction.

If the error number is not equal to the end-of file error number execution of the program will be aborted.

Notice that in Structured Basic lines may be labeled in addition to being numbered. The line label **\*Error' trap** tells us the purpose of the subroutine, where a line number alone would not give us this information. Line labels are another feature of Cromemco Structured Basic which assist the programmer in writing clear, easy to understand programs.

The procedure **.Read' and' process** calls two other procedures. They are **.Filter** and **.Decode' and' output**.

Invalid characters are filtered out by **.Filter**. The string function **Pos** is used here to determine if the character which is present in the character buffer (**Character\$**) is a valid character. This is done by finding the position of the character within a string which contains all of the valid characters

(**Valid' character\$**). If the character cannot be found within the string the **Pos** function will return a -1. This will be the case if **Character\$** contains an invalid character.

Although the carriage return is an invalid character, it is trapped in this routine and causes a space to be output. This is done because it is common to terminate words in an ASCII file with a carriage return (new line) and no space.

Valid characters are displayed on the console. If it is determined that there is an invalid character, **Character\$** is assigned the value of a null character.

Valid characters are decoded and output by the procedure **.Decode' and' output**. This procedure contains 38 subroutines, each named for the character it generates.

Take the letter **d** for example. Its value is not within the range of the numbers so that no number subroutine will be called. During the check for a lower case letter, the variable **Low' case** will be assigned a value of **4**. The **On-Gosub** instruction will transfer control to the fourth subroutine in the list, the one named **D**.

The subroutine **D** calls the procedures **.Dash**, **.Dot**, **.Dot**, **.Pause**, and then **Returns**. Both the **.Dot** and **.Dash** procedures display characters on the console and call the procedure **.Tone** to generate the required Morse code.

The procedure **.Pause** generates a pause whose duration is specified by its argument. In this case the

length of the pause is 11s (inter-letter spacing) times the length of a dot.

The 'Output' and 'decode' procedure also generates a new line on the console if the line length has exceeded the allowable line length.

If the program reaches a normal or abnormal termination, **On Error Stop** restores the standard system error handling routines and the next called procedure (**.Finish**) sends a Morse code break character indicating the end of a transmission and closes the input file.

### CONCLUSION

In summary, here are some of the important points to remember when writing a good structured program.

1. Break the program up into logical tasks. Break each task into subtasks. Continue this

simplification until each primitive procedure performs one clear and simple task

2. Use meaningful names for procedures, variables, and lines labels.
3. Use the preferred control structures, i.e., **If-Then-Else**, **While-Endwhile**, **Repeat-Until**. Try to avoid using the **Goto** instruction.
4. Use Remarks when they will help to make the purpose of a section of code clearer.

These are not hard and fast rules, but suggestions which should be followed when possible. There will always be exceptions to these, but keeping them in mind when one is designing and coding programs will allow the programmer to create better, more useable, and more maintainable programs.

My thanks to Laura King, Dr. Roger Melen, and Roger Sippel for their contributions to this article.

## Purchasing A Computer System

Continued from first page

tions. The best possible advice one can give the prospective purchaser is to fully think through and develop a game plan **before** the first contract negotiation session. The topics set out below are intended as a generalized checklist only — there are many other contract issues (legal and business) which may have to be addressed.

Since purchasing a computer system is often one of the most important decisions a business makes, it is recommended that the prospective purchaser obtain help from knowledgeable professionals in selecting a vendor and negotiating a satisfactory contract.

### 1. INCORPORATION OF PROPOSAL

It is extremely advantageous to the purchaser of a computer system to have the vendor's written proposal incorporated into and made a part of the agreement. By doing this, the vendor is, in effect, held accountable to the purchaser for the pre-sale inducements made to the purchaser. Reluctance on the part of the vendor may very well indicate an unwillingness, or worse still, the inability to comply with what is contained in the proposal. Often the give and take on the incorporation of the proposal will "smoke out" the real issues.

### 2. INCORPORATION OF SYSTEM SPECIFICATIONS

(a) In order to establish what the purchaser is buying, it is common practice to attach as an exhibit and

incorporate into the agreement the written specifications of the system. This provides an **objective** analysis of what the parties bargained for as the subject matter of their agreement. This is far preferable to attempting to establish **subjective** intent after the fact. The specifications should be as detailed as possible.

(b) The second function to be served by incorporating systems specifications is to establish time frames within which the vendor will perform and to compensate the vendor for reaching the indicated "milestones." The purchaser should always bargain for payment only upon complete performance by the vendor. This, of course, gives the purchaser the ultimate leverage and will motivate the vendor to complete performance on time. However, as a practical matter, it is often not possible to achieve such an advantageous bargaining position. In any event, the purchaser should have a sufficiently large "carrot" ahead of the vendor to ensure timely completion by the vendor.

### 3. ACCEPTANCE

When is a system installed so that it can be accepted by the purchaser? Far too often this matter is not addressed. As in the case with system specifications, an objective test should be acceptable to both parties. If the system meets the agreed-upon objective test, the vendor gets paid; if it doesn't, the

vendor keeps working until the system passes. From the purchaser's point of view the best objective test is whether the system, when installed, will produce the contemplated reports and output using purchaser-supplied data over a specified period such as a month end, in the case of a billing system.

### 4. "DROP DEAD" DATE

It is important to have a date by which the purchaser can walk away from the deal if the vendor has not completed performance. This date is commonly (although not delicately) referred to as the "drop dead" date. If the agreement has such a date, there is, once again, an objective test of performance by the vendor. One of the benefits to the purchaser of a "drop dead" date is that the vendor knows his failure to perform by that date will deprive him of the benefits of the bargain, as well as possibly subjecting him to damages for non-performance.

### 5. ENVIRONMENTAL SPECIFICATIONS

Parties to computer purchase agreements sometimes get into disputes as to who had what responsibility for preparing the site for installation of the system. This is an important area to cover in the agreement because of the expense associated with power and air conditioning equipment. It is best to handle this problem by specifying that the purchaser shall prepare

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# BASIC DISK FILE I/O

By Darwin A. Engwer  
Dynamic Systems Group



Darwin Engwer is the president of Dynamic Systems Group, Calgary Alberta. His firm serves clients in Canada and the U.S. specializing in microcomputer system design, planning and sub-systems. Generation Data, Inc., a spin-off company, honors from the Electronic Engineering program at the Southern Alberta Institute of Technology.

Engineering program at the S.A.I.T. and has been creating microprocessor based control systems for Alberta industries for the past three years.

My last article prompted some questions from several new users of Cromemco Basic concerning disk file I/O. After helping them I recalled the training required by some local customers in exactly the same area. One source of difficulties is the attempted conversion of programs written for other Basics that use PRINT and INPUT statements for accessing data files. If you are also in this predicament then read on, else stop!

Cromemco's Basic manual actually does a good job of defining the differences between using PRINT and INPUT statements for file access versus the better results obtained through the use of the PUT and GET statements, including an example program. Therefore, I will discuss only those points I have determined to be crucial to success.

PRINT and INPUT statements invoke processing of the data, which is definitely of benefit when displaying results and acquiring data from an operator; after all, that is their purpose. However, when your objective is to store and retrieve data from disk files (in a minimum amount of space) the conditions imposed by the use of PRINT and INPUT statements quickly become irritating. PUT and GET statements allow you to easily store an item at a specific location in a file and retrieve it later. Two important steps are required in order to ensure success.

The first step is to layout the record formats for your data file. A form is useful for this task, with headings like: Variable, Description, Length (bytes) and Variable Type. The format may vary from record to record, as long as the record length (declared when the file is opened) is not exceeded. For example, record zero of a file frequently contains record counts and pointers instead of actual data.

The second step requires that every time you read or write a record (or data item) you include all the matching specifications necessary to locate the fields — i.e. always explicitly specify where the data is located in the file.

## Example Program

A short example program will best convey this concept of explicit specification. The program

implements a simple phone list storage/retrieval function. Each data record consists of a 20 character name, 14 character telephone number and a group identifier stored as an integer. Total record length = 36 bytes. Record zero contains only a single integer field which describes the number of data records currently in the file

```
100 INTEGER t,N1
110 DIM NS(20),PS(14)
120 CREATE 'DATAFILE.DAT'
130 OPEN\1.36\''DATAFILE.DAT'
140 NS = "Cromemco"
150 PS = "(415) 964 7400
160 T = 1
170 PUT\1.1\NS(0,19),PS(0,13),T
180 NS = "IACU"
190 PS = "(714) 955 0432
200 T = 2
210 PUT\1.2\NS(0,19),PS(0,13),T
220 N1 = 2
230 PUT\1.0\N1
240 CLOSE
300 OPEN\1.36\''DATAFILE.DAT'
310 GET\1.0\N1
320 FOR X = 1 TO N1
330 GET\1.X\NS(0,19),PS(0,13),T
340 PRINT"Name: ";NS;" Phone: ";PS" Group: ";T
350 NEXT X
360 CLOSE
```

The data defined in lines 140 through 200 would normally be acquired from an operator using INPUT statements instead of the direct assignments shown.

Notice that each time the file I/O variables NS and PS are referenced, when writing to or reading from the file, the string limits are specified. This is the explicit specification described in step two above that insures the proper location of the fields in the data records, allowing lines such as the following one that reads only the group number from a record.

```
335 GET\1.X,34\T
```

An important feature of Basic illustrated by the example program is the ability to handle odd record sizes — this allows more compact storage of the data and relieves the applications programmer of this task. In summary, Basic disk file I/O can be very powerful — once it is mastered

## UPDATE: Single User CDOS\* Active Command File

The example program shown does work under Multi User Version 1.5, when the ACF filename is changed to \$\$\$\$n.CMD, although drive A: must be the current drive throughout the sequence. Continued

\*CDOS is a trademark of Cromemco Inc., Mountain View, California.

For operation under single user CDOS (Series 1 or 2) the following three additions are necessary:

1. The ACF must be referenced as x:\$\$\$\$.CMD (where x: can be any valid drive specifier) so that 16K BASIC does not interpret it as a peripheral device.
2. Single-User CDOS expects a different ACF record format, requiring the addition of a 3 byte field (of binary zeros) which proceeds the command string length field. The proper way to implement this is by adding line 35 and extending lines 50 and 60.

```
35 DIM BS(2) : BS = ""  
50 PUT\1.0\BS(0,2):CHR$(14):"BASIC  
    MENU.SAV": S  
60 PUT\1.1\BS(0,2):CHR$(LEN(C$)):C$  
    (0,LEN(C$)-1):"$"
```

3. The presence of the ACF must be indicated to single user CDOS. Although this can be done by calling a machine language program to make the proper jump directly into CDOS, a much easier method is to ensure that the ACF already exists. For example Batch can be used to create the ACF and invoke Basic.

```
A.@  
CROMEMCO BATCH VERSION 1.04  
!BASIC
```

Since the ACF will already exist, line 10 is no longer required. Take special care that the drive specifier added to line 20 corresponds to the drive where Batch created the ACF.

Continued from page 14

the site, but that the vendor provides the objective standards.

## 6. RISK OF LOSS

The parties should specify who has risk of loss as to damage or destruction to the system until it is accepted by the purchaser. Since the vendor has installation responsibility, it is preferable to have the vendor assume risk of loss until acceptance by the purchaser.

## 7. WARRANTIES

A critical element of the purchase agreement deals with the representations and warranties the vendor gives the purchaser. If it is later determined that the vendor is in breach of any of these representations or warranties, the purchaser may be able to rescind the agreement, as well as maintaining an action for breach of contract. Some of the more common representations and warranties are:

A. Purchaser gets good title free and clear of liens and security interests;

B. The system is new and, therefore, eligible for the Investment Tax Credit under the Internal Revenue Code;

C. The system does not infringe upon any patents, copyrights or proprietary rights of third parties;

D. The system will perform in accordance with the vendor's published specifications; and

E. The application and operating system software will operate in conjunction with the hardware so as to form a complete, integrated system which will produce the re-

ports and output set forth in the specifications.

## 8. PATENT AND COPYRIGHT INDEMNITY: PROPRIETARY RIGHTS

It is necessary that the purchaser be protected against the possibility that the hardware or software infringes upon the rights of third parties.

## 9. MAINTENANCE: RESPONSE TIME; DOWN TIME; SPARE PARTS

If the vendor will also be providing ongoing maintenance services for the system, the nature and extent of such services should be clearly indicated in the agreement. As a natural adjunct to specifying the repair obligations, the agreement should specify the response time promised by the vendor; ramifications of downtime; handling of spare parts; hours of coverage and holidays excluded. Additionally, the vendor should be committed to providing maintenance services, at the purchaser's option, for a time period equal to the purchaser's depreciation period, e.g., five years.

## 10. DOCUMENTATION

The purchaser should obtain sufficient documentation for both the hardware and software components of the system, including adequate documentation to enable the purchaser or its designee to maintain the system.

## 11. TRAINING AND SOFTWARE SUPPORT SERVICES

The vendor should agree to pro-

vide initial training in the operation of the system, as well as on-going software support services. The nature and extent of such services should be clearly spelled out.

## 12. SOFTWARE UPDATES

The vendor will invariably be enhancing the software components of the system from time to time. The purchaser should have the benefit of such updates on the same basis that the vendor makes such enhancements generally available to its customers.

## 13. PROPRIETARY INFORMATION

The purchaser probably has business secrets and other confidential information with which the vendor may come into contact during the course of the design and installation of the system. It is prudent for the purchaser to protect itself against disclosure of such secret or confidential information by having a non-disclosure provision in the agreement.

## 14. INSURANCE

If the equipment components of the system cause damage to persons or property arising from electrical failure or otherwise, the purchaser would be in a better position to recover resulting losses if the vendor has a products liability insurance policy. The purchaser should be added as a named insured under the policy.

## 15. DAMAGES FOR FAILURE TO PERFORM

The issue of damages for vendor's failure to perform is es-

Continued on page 19

# Join Now. But Don't Cut The Page. Copy This Application and Mail to IACU With Your Check.

## Application for Membership ND 80

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### My Primary Uses are:

Business  
 Education  
 Research  
 Other \_\_\_\_\_

Personal Only  
 Process Control  
 Other \_\_\_\_\_

### I am Interested in:

Software  
 Other \_\_\_\_\_

### I Want to Know More About the following Packages:

Home Economics  
 Medical Research  
 Express Type  
 Word Processing  
 Other \_\_\_\_\_

### Describe Your Present System: (use brands and model numbers)

### List Software Now In Use: (Packages, Special Operating Systems, etc.)

### What Types of Software Would You Like to know more about?

### Would you be interested in preparing an article of interest to our members?

# Custom Computer Billing Is On Line At Suffolk County (NY) Lawyers Service

by Geoff Proud\*

...the law's delay" is Hamlet's succinct phrase for an annoyance that at certain times and places affects every man. Isn't it nice to know someone is doing something about it?

Greg Galdi and Richard Robertson of Custom Computer Specialists, Inc. in Riverhead, NY recently put their local lawyers' service on a Cromemco System III with a dual floppy disk memory capable of handling the service's billing of 2000 attorneys and law firm clients. The effect of computerized management of accounts is estimated to be a 300% acceleration of business flow.

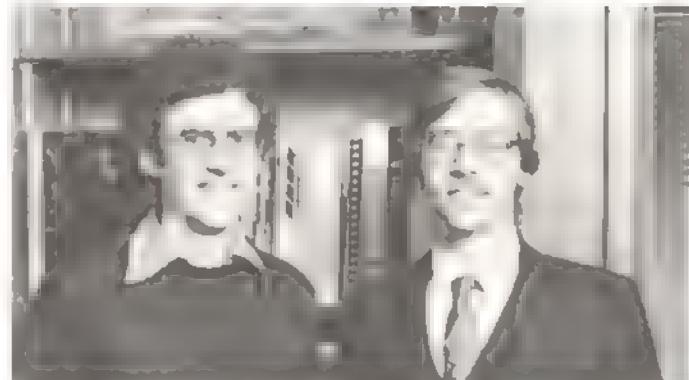
According to Suffolk County (NY) Lawyers Service General Manager Cliff Polacek, "Our billing, handled manually could fall as much as three months behind during a bookkeeper's summer vacation. With the Cromemco on line we're not only up to date but the billing department personnel have time for other work."

The firm's services for lawyers include research, such as preliminary title search and corporate ownership identifications. But its chief task is monitoring the court calendars of the county's Supreme Courts and alerting lawyers to the time and place of scheduled appearances. The calendar of civil cases is published only eighteen hours in advance. For a lawyer to be certain of the time of an appearance, he would be required to read the Law Journal every morning watching for his case to appear.

SCLS saves him time by reviewing each day's calendar for him and contacting him by phone if his case is scheduled. Every afternoon the SCLS staff of eight will make an average of 500 telephone calls informing clients of up-coming court appearances. Anyone who has had any civil court dealings is well aware of the delay caused when one of the participants fails to show. SCLS is helping to the extent that it makes it easier for the lawyers to be abreast of the schedule of assignments and be on time.

At the end of a busy day SCLS must record the calls made. Since an attorney may make a dozen appearances in court over a period of weeks before a case is disposed, or may be involved in several cases, keeping a record of calls for billing purposes is complicated. This is why a computer was called for.

SCLS management made several inquiries before they found the hardware and the system that could perform the job. They learned that large computer companies



Richard Robertson and Gregory Galdi of Custom Computer Specialists (left and right) created 'Court Calendar.'

could not handle it in a way that was cost-effective for them. They were referred to Custom Computer Specialists, a systems house in nearby Riverhead.

Working closely with the SCLS staff, Galdi and Robertson created the software for a case reference filing system which includes the names of the lawyers and the cases they are handling. At the end of the day each case appearing on the court calendar is called up on the computer screen. The bookkeeper then accesses each lawyer's account by an assigned code number and makes the appropriate charges for the calendar call. (The next time the cases appear the operator needs only to confirm the lawyers' assignments to the cases, and with a single command the computer charges the accounts.) At the end of the month a print-out provides each lawyer client's bill for services, detailed with dates of appearances, the bottom line calculated, ready for mailing.

The organization of this enormous quantity of business activity — up to 10,000 calls to be posted and billed at the end of the month — is done at a time saving rate that is incalculable. The benefit to the attorneys is that their own billing is not delayed and their accounts can be closed on time.

The software is named "Court Calendar," after the source of the data. It is built around a Cromemco System III, consisting of a keyboard and screen, a line printer, and a dual floppy disk memory. The software's creators believe it can be applied in other court calendar services with slight modifications, and that it could also be easily extended to manage other tasks in SCLS's business: payroll, research, etc. This project is in the works now at Custom Computer Specialists.

What is remarkable about "Court Calendar" is not

only the sophistication of the system but the fact that computer power, once available only to giant businesses like airlines and telephone companies, was fashioned economically to meet the specialized needs of a small business.

The key was in customizing the software to fit the unique mode of operating of the lawyers' service. Referring to Galdi and Robertson, Polacek points out that "it is such a unique billing system and they were



Lawyers Service operator inputs the daily log on a Cromemco III. A dual floppy disk stores data appearing dates of 2,000 lawyers

able to devise a program for it. They should be capable of creating a system for any kind of service or business. There is no question of the benefits to be derived now that we've gone to the Cromemco. It takes away that burdensome 'paper work' which often inhibits the growth of a small business, and it frees our personnel to practice the special skills which are needed in our business. We anticipate growing now that we have maximized the speed of handling billing. We hope we've added a modicum of speed to the pace of the law too."

Continued from page 16

sential — the difficulty involves working out a satisfactory arrangement if the parties come to a parting of the ways or there is delayed performance which is ultimately completed by the vendor. Some suggested approaches are:

- Dollar assessment or price reduction
- Right to cancel and be reimbursed for expenses and inconvenience
- Upgrading hardware at vendor's expense
- Upgrading software at vendor's expense
- Cash penalties for lost benefits during the waiting period
- Free hardware and/or software maintenance services

## 16. ASSIGNMENT BY VENDOR

Since the purchaser has agreed to deal with the vendor based upon an investigation of the vendor's capabilities and the personal relationship which evolves, the purchaser should insist that the vendor not assign the agreement, in whole or in part, without the purchaser's prior written consent.

## 17. ESCROW OF SOURCE CODE

The computer software will be written in programming code known as "source code." The ability to make changes to the programs will depend on the availability of the source code. Accordingly, in order to protect the purchaser against the unexpected inability of the vendor to perform for whatever reason, the purchaser should have the source code placed in escrow, perhaps with the purchaser's attorney as escrow agent. A safe deposit box is recommended for safekeeping of the source code by the escrow agent.

The above article is designed to provide information with respect to the subject matter covered. It has been prepared with the understanding that neither the author nor the publisher is engaged in rendering legal, accounting or other professional service. If legal advice or other expert assistance is required, the services of a competent professional person should be sought.

Continued from first page

- RATFOR
- LISP
- C
- Assembler

### Small Size

A word about the physical design of the System Zero (CS-0) and the System Zero/D (CSO/D).

First, the units are in small, identical-size all-metal cabinets. Height is minimal, only 3½". Although the cabinets are table-top in type, rack-mounting brackets are available. The shallow 3½" height is then particularly attractive, since so little rack space is taken up.

### Price

All in all the CS-0 and CS-0/D are sure to be popular with a lot of engineers, technical, business and systems people.

Prices, too are sure to be popular. The CS-0 for example, seems to be the lowest priced S-100 bus computer available (\$995).

The CSO/D or System Zero/D is priced at \$2995, and the DDF disk drive at \$1295.

## Cromemco's New Small Computer

390K of storage is with the double-sided, double-density diskettes

### Self-Test Diagnostics

A special convenience in the controller is the set of system diagnostics contained in the RDOS-2 program.

This gives the user a quick self-test of the computer and drive system to see that the memory, controller and drives are functioning properly.

### Software Support

Cromemco is known for the quality and extent of its software support.

And the list of operating systems and languages for the System Zero/D is impressive indeed:

### System Software

- CDOS
- CROMIX
- RPG-II
- COBOL
- BASIC
- FORTRAN IV

# Process Control In The Petroleum Industry

By Jerrell M. Johnson



A Boeing 747, a Lear Jet and your new car all have something in common — each has an onboard central processing unit to control specific functions. Each also requires petroleum products to operate.

I became involved in the petroleum industry when a company contracted me to help finalize the design of a transistorized burner control. (A burner is used to take the water out of oil and gas by condensation.) Having just read Dr. Harry Garland's\* book, INTRODUCTION TO MICROPROCESSOR SYSTEM DESIGN, I was convinced that the MCS-51 single chip computer could provide a more intelligent way to control the well, not just monitor it. (The National Semiconductor 800 Series, giving us a Z-80 compatible CMOS chip, became available after the initial design considerations were made.)

At this point you may be asking yourself why a Cromemco dealer would want to make a single card computer when Cromemco already had a magnificent one. A reasonable question. The answer was, power consumption. Remote well sites either do not have electric power, or it is very unreliable.

We had to design a well control board that could operate from an electricity source provided by photovoltaics. (Photovoltaics is the direct conversion of sunlight to electricity using "solar cells.") Our design incorporated solar panels which are used to recharge batteries from which the well control computer gets its power.

The next problem arose in the communications area. With hundreds of wells served by a base station

computer, and each well up to thirty miles distant, the cost of telephone lines and upkeep was prohibitive. We found the solution in UHF and VHF radio telemetry. With a transmitter and receiver at the base station computer, and the same at each well site, we solved the communications needs.

Now, back to well head control. Before automation through computerization, all well sites and compressor stations had to be manually inspected by a "pumper" as a method of preventative maintenance. Typically, a pumper is in charge of the maintenance of a large number of wells. In the larger oil fields, most of the pumper's time is spent in driving from well to well. Since the installation of our computerized control system the pumper goes only to those wells in need of repair or maintenance, knowing in advance the exact problem at the site.

Another area which required attention was the natural gas industry's special need to control "burners." When a flame out occurs (and it often does) as the sour gas used to fuel burners has a low BTU level) the fuel supply must be instantaneously shut off. Otherwise, the deadly gas will escape into the atmosphere. The burner itself must also be completely purged before attempting to relight — something a pumper could not always do properly, occasionally resulting in a vessel explosion.

Our solution was to devise a method of monitoring the flames for which we introduced an ultraviolet detector. Since all flames produce ultraviolet radiation, we determined we could use this device to monitor both the presence and the quality of the flames. In other words, an ultraviolet detector can distinguish between main and pilot flames, so we were able to monitor both the main burner and the pilot. (Infrared flame detection is a viable option, and we are presently working with C.C.D. memory chips toward this end. One of the C.C.D. chip's serendipities is its ability to detect subtle differences in light intensity in the red and infrared regions of the spectrum.)

The last tasks for well head control included accurate accounting of each well's production (this was accomplished with flow reading built into our system); and the control of certain functions such as holding tank levels, and the temperatures and pressures of various processes. These tasks were turned over to the well control computer which, with its instant access to well status, usually reacts to correct any problem. If the problem cannot be corrected on site, the base station computer takes charge via the well control computer's transmitter.

For the more technically minded, our well control computer, built out of the NSC 800 Series single chip

computer provides 82 optically coupled digital and 32 optocoupled analog input sensors. There are 32 digital output pins and 16 output pins with common ground. The data transfer computer via a high speed, full duplex serial link. AS and RS are two prioritized external interfaces and there's real time data storage for up to 1K bytes.

To protect the whole system computer from the harsh environment where it is inserted into a sealed enclosure and buried 10 feet underground. The temperature is a constant 60° Fahrenheit at this level.

The basic system can be configured in several different ways. Our basic computer is 50,000+ dollars and includes a monitor, keyboard, tape drive, and two disk drives. The tape drive is used to store the monitor's boot code and operating system. The two disk drives are used to store the application programs. The monitor is a CRT type, the keyboard is a standard 101 key model, and the tape drive is a 1600 baud unit.

For the first year we will offer three different levels of software. The computer is supplied with a basic program and a set of 100 programs plus memory, disk drives, and monitor. After one year we will add a second level of software. This will consist of 100 more programs, plus memory, disk drives, and monitor. The computer will then have a third level of software. This will consist of 100 more programs, plus memory, disk drives, and monitor. The computer will always be upgradeable.

Our primary computer consists of a Z8000, 3703 processor, 1M of memory, and a System 2 programmed in RAYFOR. It is equipped with a 10" Processor and a monitor running at 1200 baud with the UHF or VHF radios, but also, with the company's own interface.

In our SUPER SYSTEM we replace the System 2 with a Z2 H GS Graphics System and a 13" RGB Monitor. This system displays each website graphically, and indicates any function not up to specification in RED.

Our manufacturing and quality control will be using the Cromemco System Two and System Three to run burn in tests of the whole control computer. Software is written in RAYFOR and 32K SBASIC. Multiple D+7As (digital analog boards) are used to eliminate a working well and all problems that we can anticipate.

Full production of the web contro computer will not begin until the third quarter of 1981 due to the limited availability of the NEC 8038, in production quantities.

The costs for our web contro computer are \$1,350.00, with transmitter/receiver, solar panel, and battery pack total about \$1,600.00. With 50,000+ a system and with a 10% annual depreciation rate, the daily operating cost is \$1.80 and that's very little considering the 100,000+ hours per year. At an 11% interest rate the cost is \$1.75 per day. An operating cost of roughly 90 seconds, per day.

A 2000' cable length is the absolute maximum distance for the power supply to the computer.

I would like to thank those who have helped me in the creation of this system. I would like to thank Eric and the other people at Logistic Concepts for helping me in the design of the web contro computer.

\*Logistic Concepts may also be contacted in regard to their mini uninterruptable power supply for business users who need uninterrupted condition AC power.

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# The C-Bus, IOP, and QUADART

Continued from page 1

cessor (Cromemco's new IOP) which drives an overhead ribbon cable expansion bus called the C-bus. Special I/O cards, such as the new QUADART serial communication card, are controlled by the IOP through the C-bus. The system designer may add as many C-bus systems and/or stand-alone IOPs as needed to distribute the processing workload. Figure I shows a typical application.

diminishing returns since the basic bandwidth of the bus is fixed. In C-bus systems, the bandwidth of the S 100 bus is not a limiting factor because the added processors use their own independent expansion buses.

One way to envision C-bus I/O is as an intelligent I/O channel. That is, the main processor issues a command (or chain of commands) and data to the I/O device and then



**Figure I.** In a typical application the C-bus brings distributed processing to a Z2 H order entry system. Eight remote entry terminals are handled by a C-bus system composed of an IOP and two QUADARTs. A single IOP performs data encryption/decryption. The high speed link to a mainframe computer is handled by another IOP/QUADART system.

The C-bus allows FUNCTIONAL MULTIPROCESSING. That is, as tasks are added to the system (e.g., new I/O devices, new software subfunctions like data encryption or vector generation, etc.) a dedicated processor is added to take care of that task. The main processor is "offloaded" and the efficiency of the system goes up.

An important aspect of the C-bus is that each I/O processor has its own independent expansion bus (the C-bus). It is as though the processor were in a separate box, since there is absolutely no interference with the S 100 bus. This is in contrast to a multi-master bus, where multiple processors compete for the use of a single main bus. In a multi-master bus the addition of more and more processors brings

goes away while the I/O device performs tasks such as initialization, data transfer, error checking, and data manipulation.

In a stand alone mode, a C-bus system can perform useful tasks even without the presence of a host processor. This is possible because the C-bus is completely independent of the S 100 bus, except for power supplies. With an IOP and QUADART card set, as shown in Figure II, for example, a user can implement a number of useful functions including line multiplexing, data concentration, protocol conversion, data monitoring, and so on. And these functions can be included INSIDE the user's main machine, too!

In short, the C-bus provides a powerful tool for the design of

high-performance S 100 systems — because it provides structured solutions to a wide range of problems.

## The C-BUS Explained

The C-bus is very flexible: it comprises a set of Z-80 processor signals, control lines, and ground returns which are routed along a fifty-wire ribbon cable. A number of advantages accrue from the use of ribbon wire. The first is, that there are no mechanical modifications required of the host in order to install the new bus; the ribbon cable simply runs along the top of the added cards to interconnect them. Installation of a powerful C-bus system is thus as simple as plugging a few cards into the S-100 bus and plugging in the C-bus ribbon cable. This simplicity (and retrofit capability) is unique to Cromemco.

Another feature of the C bus is that it is "incrementally expandable." The number of "slots" (actually plugs) on the C-bus is set to match your system so that you only pay for what is needed. If, however, the system is expanded at a later date it is a simple matter to remove the old C-bus and install a new C bus with a different number of plugs.

While the total number of cards in your system is set by the size of the S-100 bus (i.e., 4 slot, 8 slot, 12 slot, etc.), there are no constraints on allocation of these slots between host system and C bus system. An I/O intensive system might use 75% of the slots for IOPs and QUADARTs and only 25% for the host while a memory intensive system might have a ratio just the reverse. The freedom to partition hardware between host and I/O in this manner is another unique advantage of the Cromemco C-bus.

The signals on the bus are, for the most part, buffered signals from the Z80 CPU chip, as shown in Figure III. This tends to tie the bus to a specific processor, of course, but has the overriding advantage that the family of Z80 peripheral chips may be efficiently used. In particular it allows the full power of interrupt chaining to be realized.

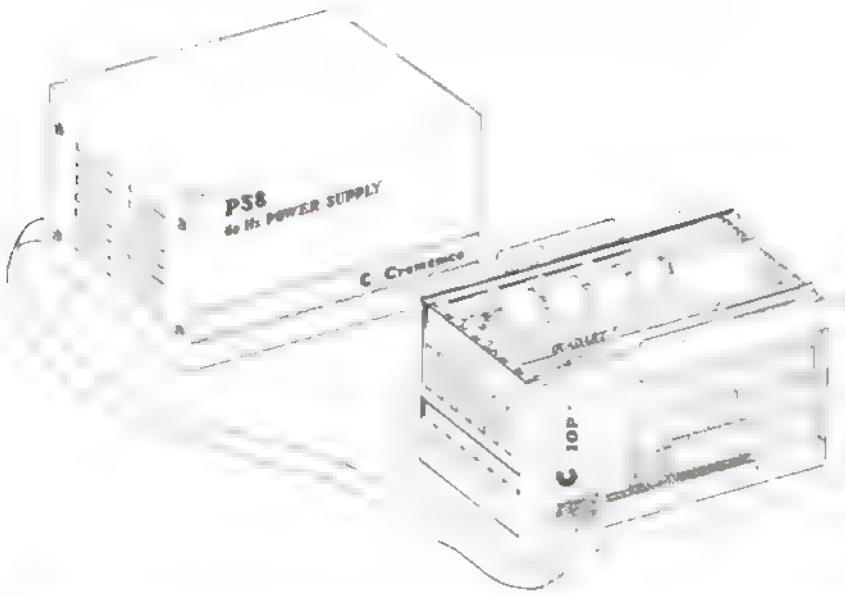


Figure II. A photograph of a Cromemco Z-80 computer system showing the main unit and the C-Bus controller.

### C BUS

PIN	SIGNAL	PIN	SIGNAL
1	GROUND	26	AIO
2	RESET	27	AII
3	Φ	28	GROUND
4	GROUND	29	AI2
5	WAIT	30	AI3
6	DΦ	31	AI4
7	D1	32	AI5
8	D2	33	RD
9	D3	34	GROUND
10	D4	35	WR
11	D5	36	M1
12	D6	37	MREQ
13	D7	38	IORQ
14	GROUND	39	RFSH
15	AΦ	40	CPU DISCONNECT
16	A1	41	BUS AVAILABLE
17	A2	42	HALT
18	A3	43	GROUND
19	A4	44	INT
20	A5	45	NMI
21	GROUND	46	1st PRIORITY IN/OUT
22	A6	47	2nd PRIORITY IN/OUT
23	A7	48	3rd PRIORITY IN/OUT
24	A8	49	1st PRIORITY IN/OUT
25	A9	50	GROUND

INTERRUPT CHANNEL  
DMA CHANNEL

Figure III  
Included for

There are six bus signals which differ from Z80 signals. Three are used to handle the transfer of the C-bus from IOP control to remote control. This will allow future devices to run high speed control and data lines across the C bus to communicate between boards during critical operations. While the C bus is being used by the remote device(s), the IOP continues to process but it is limited to on board memory and I/O. The three bus transfer lines are called CPU DISCONNECT/, BUS AVAILABLE/, and PRIORITY. The first two are request and acknowledge signals, respectively; the third is for daisy chaining two remote devices.

The remaining three signals not associated with the Z80 CPU are used for the interrupt priority daisy chain. These wires allow a total of four boards to be chained without an external connection. If more than four boards are used they can be chained through an external connection which is similar to the Cromemco S-100 daisy chain.

### The IOP

The C-Bus controller, called the IOP, is shown in Figure IV. On a single card it includes a 4 MHz Z80, 16K of RAM, up to 32K of PROM or ROM, the C-bus interface and buffers, and two parallel ports for communication with the host processor. It provides the capabilities of a ZPU, a 16KZ, a 32KBytesaver, and two parallel ports; yet it costs about half as much as the sum of these components and consumes less power and less space.

The IOP communicates with the host through two S-100 I/O ports. One port set is for Command/Status, the other port set is for Data In/Data Out. In other words, the IOP looks like a simple UART to the host. Since only two I/O ports are used many IOPs may be in a single system. A block diagram of the IOP is shown in Figure V.

If desired, the IOP may signal the host through interrupts. The IOP's interrupt vector to the host is software programmable. The IOP also

supports the S-100 daisy chain priority scheme which is common to Cromemco I/O cards

An unusual feature of the IOP is that it may reset the host processor. This makes the IOP valuable as a watchdog, for it can reset the host from a runaway program (the IOP would be programmed to receive periodic "handshake messages" from the host, and would issue a bus reset if these messages were absent for an extended period).

The IOP can communicate with up to 252 I/O devices on the C bus. Four ports are taken up by the S-100 interface and an on board control/flag port. The IOP can also address off board C-bus memory for future expansion.

The IOP may be interrupted by any C-bus device. The C bus has its own daisy chain which is similar to the S-100 daisy chain. However the C-bus daisy chain does not require an external wire if fewer than four devices are chained.

The IOP may also be interrupted by the host, if desired. In this mode the IOP is interrupted whenever the Host reads or writes the IOP's S-100 I/O ports or if the host acknowledges the IOP's interrupt.

An unusual feature of the IOP is that the type of memory as well as the addressing is controlled by a bipolar PROM. The normal configuration is to have four ROM slots configured for 2716s addressed from 0 to 8K, nothing from 8K to 16K, and RAM from 16K to 32K. The resulting memory map is shown in Figure VI.

However, many users will want to use 64K masked ROMs and thus will re-assign the memory to have four ROM slots for 4764s from 0 to 32K, with RAM from 32K to 48K. Or some may want two sockets of masked ROM and two sockets of EPROM, perhaps 2532s. All of these options are possible and easy; it is only a matter of changing the addressing bipolar PROM.

### The Quadart

The first peripheral for the C-bus is a four channel serial I/O interface called the QUADART, shown in Figure VII. Because each serial channel supports asynchronous, bit-synchronous, and byte synchronous communications protocols, the QUADART solves many problems which the TUART could not begin to tackle; yet the price per channel is no greater. The QUADART has a powerful set of interrupts which include modem status sensing, data buffer sensing, and general purpose timers. Diagnostics are aided by the extensive loopback ability in which any channel's local or remote source of data can be connected to any other

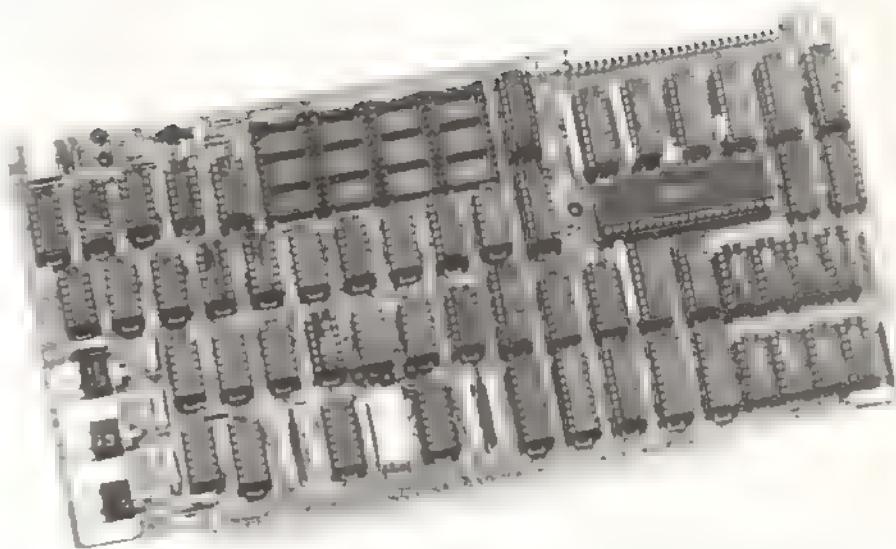


Figure IV. The IOP is a complete computer, including ROM, RAM and I/O. Two I/O ports are used to talk to the host processor, while the remainder are reserved for C-bus peripheral cards. To the host, the IOP interface looks like a simple UART.

channel's local or remote data receiver. Diagnostics are further aided by LED indicator lamps which monitor the status of seven modem lines per channel. (There are 28 LEDs on the board.) Of course the IOP controls the QUADART which ensures maximum throughput and eliminates the possibility of dropping characters while the main CPU is

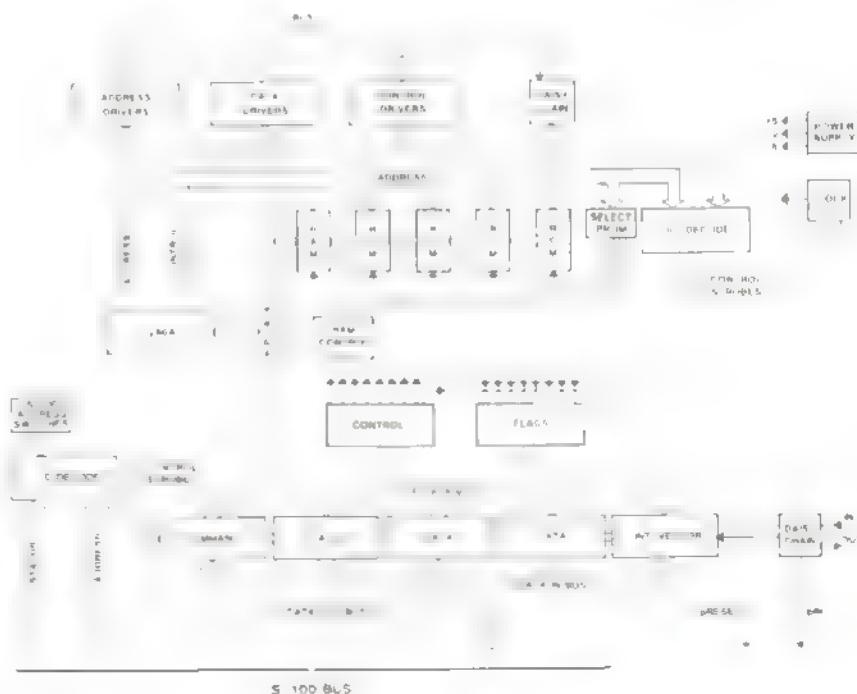


Figure V. The IOP is a complete computer, including ROM, RAM and I/O. Two I/O ports are used to talk to the host processor, while the remainder are reserved for C-bus peripheral cards. To the host, the IOP interface looks like a simple UART.

busy with the disk

### Asynchronous Communications

The QUADART allows software selection of character length from 5 to 8 bits per character. This allows codes other than ASCII to be used (e.g. Baudot). The baud rate is software selectable through a counter/timer chip to allow many different rates. A complete complement of modem handshaking lines are included and wired to both DTE and DCE style connectors for each channel so that it is just as easy to drive a terminal as a modem.

### Synchronous Communications

One of the major features of the QUADART is its ability to speak IBM-compatible BISYNC. This includes hardware CRC, programmable sync characters, and a wide speed range. These features allow

### ADDRESS

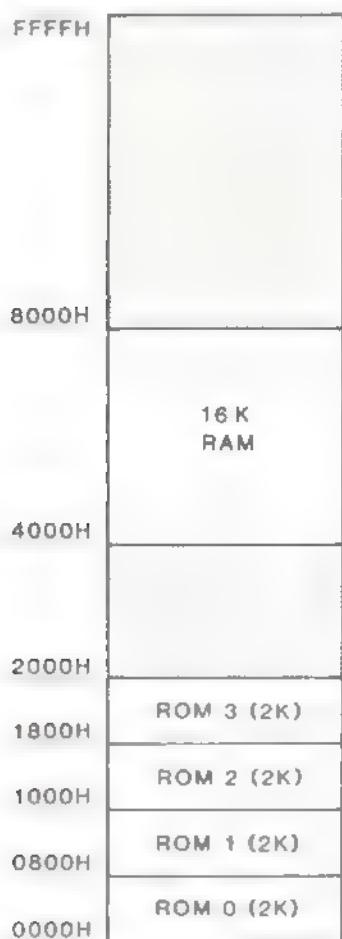


Figure VI. The memory of the IOP is factory configured a certain way, but can be rearranged by the user for any application of 2K, 4K and 8K byte ROMs, PROMs

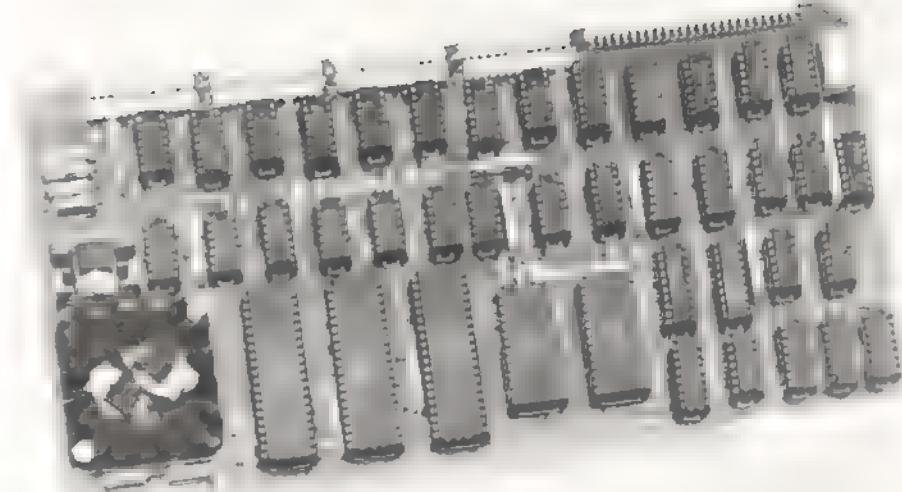


Figure VII. The Cbus IOP is controlled by the Cbus system bus. It has four serial channels, includes a full set of modem control logic, as well as local memory.

connection to IBM computers as well as some types of serial tape drives. It is also possible to connect to DEC equipment using the DDCMP protocol. The QUADART covers the future with SDLC, HDLC, and x.25 compatibility. This includes hardware address recognition, zero insert/delete, CRC and fill characters. These features are especially desirable for networking.

### What's Ahead for the C-bus?

Today's C-bus components, the IOP and QUADART, provide a number of valuable capabilities. These include full asynchronous/ synchronous serial communications handling and control by a dedicated processor. Future C-bus components are being developed which will provide the system designer with other powerful tools for intelligent I/O and distributed processing.

The new C-bus promises to be the I/O standard of the next generation of machines. By allowing the CPU to be devoted to executing the user's software with I/O and other dedicated processes handled independently, it speeds up the machine's operation. An equally important advantage is the elimination of CPU-dependent device drivers, which, in the tradition of Cromemco "Obsolescence Insurance," ensures that you can upgrade in the future without penalty.

### About the Author



Jim Terwilliger learned about computers and Cromemco when he entered graduate school at Stanford in 1975 as a teaching assistant to Hartley Elmer and in a machine

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# RGB-13 Color Monitor

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Cromemco recently announced the RGB 13, a high resolution, RGB color monitor for use with Cromemco SDI graphics systems. The RGB-13 is ideal for displaying color or black and white images with Cromemco's SDI graphics interface — which provides up to 754 by 482 point resolution.

The powerful Cromemco graphics system and the RGB-13 are especially suited to applications in business, medical imaging, process control, industry, education, computer aided instruction, science and a wide range of professional fields. In addition, the system conforms to the NTSC standard RS-170 which makes it ideal for applications in the television industry.

The Cromemco RGB 13 monitor has a fine-pitch 13

shadow mask and a high-precision delta-configuration electron gun. The monitor is self converging and features internal magnetic shielding and an implosion protection band. A long-persistence phosphor guarantees a flicker-free screen. The RGB-13 monitor is an all-solid-state design with the exception of the CRT. This solid state design ensures reliable, trouble free operation.

The Cromemco RGB-13 monitor offers unparalleled operation and cost-performance to the user interested in advanced alphanumeric and graphic display capabilities. The monitor (Model RGB-13) comes in a case with a swivel base and is available for \$2995. through Cromemco dealers.

# bits & bytes, nibbles & tweaks...

## SOFTWARE REVIEW

A few members have asked for a review of the current versions of all Cromemco software. We passed this one back to Cromemco, and they responded as we thought they would. By next issue, we will have a complete listing of the current versions, plus some other good news for users of Cromemco software.

## NEW USERS' GROUP

A new users' group has been formed on the Eastern seaboard. Called The South Jersey & Pa. Iv Cromemco users Group the initial meeting was held in November. The group plans, in addition to monthly meetings, to sponsor seminars on the use of Cromemco systems and peripherals with special emphasis on practical applications. There will also be opportunities for members and guests to share software discoveries, and to hold open discussions on new technology. If IACU members in that part of the country would like to attend an introductory meeting, call Carol Bates at (609) 854-1333 for information as to the time and place of the next get-together.

## HELP!

If anyone out there knows of a good job cost package, let us know. We have members from literally all over the world looking for software for costing jobs from divisions of factories to engineering applications to construction projects — small and large. If you happen to be a genius programmer with some extra time, and can move fast, get on this. It is apparently an area of massive demand.

## ATTENTION WEST LOS ANGELES

We received a letter from a member in Santa Monica, California who would like to meet, formally or informally, with users in his area. This could be the start of a new, local users' group. One of the things he'd like to start discussing and exploring is 32K SBASIC. He'd also like to explore the capabilities of DBMS. He has a System III, and will provide the meeting place. If interested, contact IACU.

## MEDICAL SOFTWARE

One of the strong areas of interest is in medical software — research, testing, or what have you. And if you do have some, we'd love to hear about it. Along these lines, a member in Hamburg, New York sent us some information on an application package for the individual psychiatrist or psychologist office, psychiatric clinics, or almost any type of counseling center. The software is presently written only in Cromemco's Multi-User BASIC, but is in the process of

being converted to Cromix and Extended BASIC. Please contact IACU if you want more information on this, or if you are aware of any other medically oriented software.

## SHIPPING EXHIBITION

Oslo, Norway hosts a major international exhibition for the shipping and off-shore industries May 11 - 16, 1981. Called NOR SHIPPING '81, the event attracts participants from all over the world. A Cromemco dealer in Oslo is exhibiting at the show and is looking for software applicable to shipping. Please contact IACU if you are aware of any software in this field.

## OBSERVATIONS & SUGGESTIONS

A System III owner in Grand Rapids, Michigan, and a 20-year business programmer, sent us a list of suggestions. One dealt with Cromemco's manuals, and we'd like to see how many of you feel the same way. His suggestion was to publish all manuals in loose leaf form (unbound), punched to fit a three-ring binder. Then, changes and updates could be issued as revised pages.

Another of his suggestions was to have changes and updates of Cromemco software announced through I/O News, along with costs for revised versions. (We already had this one in the works, and will probably have an up-to-date listing in our next issue.) He also had a couple of observations on Cromemco's COBOL which may be of general interest. We have turned these over to Cromemco to peruse. We will keep you posted.

## THE GREAT SHUGART DRIVE MYSTERY

Last issue, we printed a plea for help from Clarence Laney who is trying to convert his system from CDOS 1.07 to 2.17 retaining his SHUGART 801 DRIVES. This spurred several more letters from other members with the same problem. It also generated this response from Tom Feitton in Vancouver, British Columbia:

"...should be more specific. SHUGART SA800-1 is soft sectored: SA801-1 is hard sectored: SA800-2 and SA801-2 include a data separator circuit as do the Persci 277 disks...Therefore, the SHUCART SA800-2 is most similar to the Persci 277."

Okay. Now that we have that distinction, let's turn to a note from Mike Smith from Athens, Tennessee:

"There is apparently an undocumented portion of CDOS that may be of help to Mr. Laney. When the CDOSGEN asks for S or L disk, answer with X. You will then be asked for fast or slow as well as other information which is skipped if you answer S or L."

We hope this helps

We also hope it helps others who responded to the question not with answers, but with similar questions. Please let us know.

## TYVEK ENVELOPES

Part of Mike Smith's letter read:

I know that you want the I/O News to arrive in good condition, but don't you think Tyvek envelopes are a bit much?

Mike, we are sending I/O News via air mail. We have to pay extra postage for parts of the world. In addition, it

Frank [redacted]

## ATTENTION LISP USERS

Lois Flynn, author of the excellent article on Cromemco's LISP that appeared in our first issue, has a request of fellow LISP enthusiasts. San Francisco is the host city for an annual event called COMPUTER FAIRE. The next event is in the spring of 1981 (March or April, we're not certain). If you have developed any demonstrations of LISP applications — whether they be games, business, education — whatever, and you would like to see your branch displayed (or displayed yourself), contact IACU with a brief description. We will see that it promptly gets into Dr. Flynn's hands.

## SOFTWARE UNDER DEVELOPMENT

Garry Arko of Calgary, Alberta, and one of our early members, just advised that he is working on two packages which will be of interest to several of us. One is a cost estimating system for the printing industry. The other is — now get this — A GENERAL APPLICATION JOB COSTING PACKAGE. The bad news is, neither will be ready for volume distribution until next Spring, at the earliest.

## TECHNICAL QUESTIONS

A member in Silverspring, Maryland wants to interface a System III with an IBM 370 using 3270 protocol, and needs the proper software. Any suppliers? In addition, he wants to know if a plotting package for the spin writer software exists, and he is looking for a stand alone set of sub-routines to run statistics. If you can help with any or all of these, contact IACU.

## ARTICLE NEEDED

A Dearborn, Michigan member has asked for an article on adding device drivers to Multi User BASIC. Anyone out there want to have a go at this one?

## MEETING IN WALNUT CREEK

The Cromemco Users' Group of Walnut Creek will meet next on January 8, 1981 at 7:30 p.m. The subject for discussion will be Data Base Management. Interested users may get additional information by calling (415) 935 6502.

## BINDERS

We are awaiting delivery of the binders we ordered for all Charter Members. (Everyone joining during our first year is a Charter Member.) As soon as we receive our first shipment, we will start forwarding by separate mail. Look for your binder starting in January.

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**FOR SALE: Cromemco  
Multi-User BASIC  
Software and manuals.  
(415) 332-4443**

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**SAN FRANCISCO  
WANTED: Programmers  
in the S.F. BAY AREA.  
(415) 332-4443**

# We admit, this is pretty good work for a five year old.

ONE HALLOWEEN NIGHT A ghost  
POPPED OUT OF THE WOODS.  
WOLF-MAN HOWLED AT THE MOON.  
BATS FLEW AROUND WOLF-MAN.  
THE HEADLESS HORSE-MAN CACKLED.  
~~A skeleton was rising from his grave.~~ A WILD FLYING past the  
grave-yard which was stirring her  
BREW. AND I WAS SO SCARED.  
I ran all the way home.

But, what could children do if there were a treasure chest of Educational Software available? Many of our members are looking for such software. Do you have any, or know of any? If so, please contact IACU.

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### FORTRAN Subroutines for Opening Files

by Dr. Jerome J. Tiemann

**MICAH SUPER BIOS**  
A CP/M Emulator  
News of an 8-bit,  
1200 baud modem  
Software Evaluations  
Article on an  
Overlay Linker

# MEET SASI.



SASI's name comes from Satellite Accounting Systems, Inc., a whole new generation of software. SASI comes in two packages...a Master Package for Accountants or Controllers, and a Satellite Package for clients or departments. The packages can be purchased separately or together, as needed. Each is designed to work independent of the other. SASI stays in step with the times. She operates with single or multi-users, on either CDOS or CROMIX. Her sole desire is to help her bosses. She accepts information quickly and posts directly to a General Ledger. From there, she produces Income Statements and Balance Sheets. SASI can be pretty sophisticated, too. She handles a Disbursements Journal by providing easy 10-key entry to produce Vendor/Employee related output. And, if Vendor/Employee numbers are not available, she lets her boss revert to an alpha input.

Upon completion of any task, SASI allows her boss to review the whole body of material and make any corrections before she posts to the General Ledger. She even makes certain that those required annual memos (W-2s & 1099s) are ready to mail on command.

SASI likes to know what's going on, and, with a simple phone call, she can gather a wealth of information for her boss. She records everything she hears for review. Because she can't stand wasting time looking for details, SASI traces every bit of data through a series of built-in Audit Trails. With all these talents, she manages to maintain a balanced approach to everything.

SASI loves to make her boss look good, so she applies a lot of her own talents at his command. Things like Cover Letters, Footnotes, Trial Balances, and comprehensive financial statements with Budgeting and Comparative Analyses, and detailed Sources and Applications of Funds Reports — all at the push of a button or two.

If SASI sounds like the kind of girl you've been needing at your office, give us a call. She's very available.

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## SATELLITE ACCOUNTING SYSTEMS, INC.

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Newport Beach, CA 92660  
(714) 851-0783

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# New System Diagnostics Software Available

A new System Diagnostic Software package is now available for use with Cromemco microcomputer systems. The package is designed to exercise, test, and report any errors found in the operation of the 5" or 8" floppy disk drives or the 8" hard disk drives used in Cromemco computer systems. It is designed to greatly facilitate the trouble-shooting and repair of Cromemco systems. Perhaps more important, this software can be used to pinpoint latent problems before they affect the actual operation of the computer system.

The diagnostic software is completely menu driven and allows the user to build a sequence of different tests in any order desired, or to select a default sequence by pressing a single key. The automatic mode allows the execution of a sequence of tests from 1 to 32,767 times. The operator may select either a pre-defined sequence which exhaustively tests all functions of each drive, or a user-defined sequence of tests.

Errors are logged into a circular queue which resides in memory between the program and CDOS (Cromemco's Disk Operating System). Errors may be displayed either before or after all tests in the sequence have been completed. Further, errors can be echoed to a printer or written into a permanent disk

file for later reference.

The single-test mode allows the user to select a single test which the program executes immediately. The result is displayed on the terminal and another test may then be selected.

The diagnostic software is available through Cromemco dealers on 8" floppy diskette (Model CDS-L) or 5" floppy diskette (Model CDS-S) for \$195.

## PS-8 Power Supply

Cromemco's new, rugged PS-8 Power Supply is designed to power microcomputer systems configured with the Cromemco 8-slot card cage (Model CC-8) and any combination of S-100 boards. The performance and reliability of the Cromemco PS-8 make it ideal for OEM or individual requirements.

The PS-8 provides one output of +7.5V/12A, +14.5V/2.5A, and -14.5V/1.0A. The ferroresonant transformer maintains output voltage under variable input voltage conditions. The special cable included with the PS-8 allows easy interconnection of the power supply and the Cromemco 8-slot card cage. A system reset switch is built into the power supply.

The PS-8 is designed for 110-or 220-volt operation. Ambient temperature operation is from 0 to 55 degrees Centigrade. The PS-8 measures 5.56" H x 9.87" W x 8.0" D, and is available through any Cromemco dealer.

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We are looking for intelligent, honest, and competent people in the following areas.

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Now, CSSN breaks the barriers to hard disk applications by offering the complete hardware and software solution for data security...



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## Software provides:

- File by file save and restore operation using standard CDOS™ file naming conventions
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## Hardware provides:

- 6400 BPI cartridge tape drive with power supply
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# Cromemco accepts your challenge, Data General

Yes, Data General, we saw your ad.

So we realize you hope to win over some of our computer business.

And we can see you have reason to be pleased about your line of minicomputers. They are MINIs though.

But Cromemco produces state-of-the-art MICROcomputers.

Powerful ones.

And our micros have some outstanding advantages.

For example, **Cromemco is the only microcomputer manufacturer to support a broad range of microcomputers with (a) 5-inch**

**double-sided, double-density floppy disk drives and with (b) 8-inch double-sided, double-density floppy disk drives AS WELL AS (c) 8-inch Winchester hard disk drives.**

That means, of course, that our customers have a wide choice of disk storage capability.

## UNEQUALLED SOFTWARE SUPPORT

OK. That was one point.

Here's another: our stunning selection of software support. **Cromemco is the only micro manufacturer to produce both single-user and multi-user multi-tasking computers with software like this:**

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- CDOS (a CP/M-like operating system)
- CROMIX (a UNIX-like operating system)
- RPG-II (IBM-compatible)
- COBOL
- BASIC
- FORTRAN IV
- RATFOR
- LISP
- C
- Macro Assembler

### APPLICATION SOFTWARE

- Word Processing System
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- General Ledger
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**All of this is available now with more coming all the time.**

So there you are, D.G.

You can see why we know our microcomputers will stand the test.

Cromemco eagerly accepts the challenge.

## WE'RE BUSTING THE COMPETITION'S BOARDS AGAIN.

Reproduced from the July 31, 1980 Issue of Electronics magazine.

Announcing MBC/2 and MBC/3, the newest members of Data General's growing family of microNOVA™ board computers. They're the best computers on a board money can buy. You get up to 64K bytes of memory, serial and parallel I/O lines, and software support from MP/OS, our famous micro operating system. You even get supporting languages like MP/PASCAL and MP/FORTRAN IV. See for yourself.

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RAM (bytes)	32K	48K	64K	32K	48K
ROM (bytes)	4K	8K	16K	8K	16K
Processor	Intel 8080				
Memory	32K	48K	64K	32K	48K
Ports	2	2	2	2	2
Serial	1	1	1	1	1
Parallel	1	1	1	1	1
Keyboard	1	1	1	1	1
Monitor	1	1	1	1	1
Power	1	1	1	1	1

The competition will always sing the praises of their little single board computers. But from now on they'll be doing it falsetto.

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Cromemco logo on  
computer board shown  
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